EE448/528 - Analytical and Computational Methods in Electrical Engineering I
Fall 1998

Instructor:
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Office Hours: Tue., Thurs. 5:30-6PM (after class), Fri. 3-5PM, or by appointment

Class Material:
1. Class notes available on the EE448/528 web page
2. R.L. Smith, *The MatLab Project Book for Linear Algebra*, Prentice Hall, 1997.

http://eb-p5.eb.uah.edu/ece/courses/ee448/

Prerequisites:
Signals and Systems (EE382 or equivalent), Introduction to Linear Algebra (MA244 or equivalent), a working knowledge of MatLab (or equivalent)

Grading:

Homework	10%
Short Quizzes (3)	10%
Two Major Exams	50%
Final	30%

Course Goal:
The course will provide extensive coverage of numerical linear algebra, focusing on algorithms and capabilities that are incorporated into MatLab. Applications of the material will be given in the areas of image compression, the least squares fit of a line to a data set, and n-port electrical networks. While not a course on the program, MatLab will be used extensively.

Partial List of Topics:
I. Numerical Considerations
- Floating Point Representations: Single and Double Precision Formats
- Floating Point Representations: Normalized and Denormalized Numbers
- MatLab's Response to Overflow and Underflow Numerical Exceptions
- Machine Epsilon
- Rounding
- Catastrophic Cancellation
- Stability of Numerical Algorithms

II. Numerical Linear Algebra
- Vector Spaces
- Linear Dependence/Independence
- Dimensionality
- Basis
- Subspaces, Their Sum and Intersection
- Linear Varieties (Linear Manifold, Flats)
- Inner Products
- Vector Norms and MatLab's Vector Norm Functions

- Holder and Cauchy-Schwarz Inequalities
- Orthogonal Complement of a Subspace
- Linear Transformations, Range and Kernel, Rank and Nullity
- One-to-One and Onto Properties: The Existence of an Inverse
- Existence and Uniqueness of Linear Transformations Between Subspaces
- Matrix Representation of Linear Operators
- Symmetric/Hermitian Matrices and Their Properties
- Change of Basis: What Happens to the Matrix Representation of a Linear Operator
- Similarity Transformations
- Matrix Norms and MatLab's Matrix Norm Functions
- Row Echelon Form (Hermite Normal Form)
- Elementary Operations and Elementary Matrices
- Linear Algebraic Equations: Consistent and Inconsistent
- Necessary and Sufficient Conditions for the Existence of Solution(s) to $A\vec{X} = \vec{b}$
- Method of Representing Solution Set of $A\vec{X} = \vec{b}$
- Linear Functionals and Their Representation
- The Adjoint Operator A*
- The Four Subspaces Associated With A and A*: $\text{Range}[A^*]^\perp = \text{Ker}[A]$, $\text{Range}[A]^\perp = \text{Ker}[A^*]$
- Fredholm Alternative as Applied to the $A\vec{X} = \vec{b}$ Problem
- Minimum Norm Solution to $A\vec{X} = \vec{b}$ for $\vec{b} \in \text{Range}[A]$
- Orthogonal Projection of One Vector onto Another
- Gram-Schmidt Procedure
- The Singular Value Decomposition of an $m\times n$ Matrix and MatLab's SVD Function
- Singular Values, Right and Left Singular Vectors
- Orthogonal Projection of a Vector on a Subspace: Projection Operators
- SVD Related Projections
- SVD Expansion of an $m\times n$ Matrix
- Application of SVD: Numerical Rank (ε - Rank) of a Matrix
- Application of SVD: Condition/Sensitivity of Linear Systems and Error Bounds
- Application of SVD: Image Compression
- MatLab's COND Function
- Minimum Norm Solution to the Least Squares Approximation for $A\vec{X} = \vec{b}$ for $\vec{b} \notin \text{Range}[A]$
- Moore-Penrose Inverse (Pseudo Inverse)
- MatLab's PINV( ) and \ (back slash) Functions
- Application of Pseudo Inverse: z Parameters of N-Port Electrical Networks in Parallel
- Application of Pseudo Inverse: Least Squares Fit of a Straight Line to a Set of Data
- Eigenvalues and Eigenvalues of a Linear Operator
- Geometric and Algebraic Multiplicities of Eigenvectors
- Necessary and Sufficient Conditions for the Diagonalization of a Matrix
- Jordan Canonical Form of a Matrix
- Function of a Matrix

Reference List:

Hardware/Software/Floating Point Representation

[1] The MathWorks, *MatLab Reference Guide.*
[2] The MathWorks, *MatLab User's Guide*.

[3] D. Hanselman, B. Littlefield, *Mastering MatLab 5: A Comprehensive Tutorial and Reference*, Prentice Hall, 1998.
[4] Intel, *80387 Programmer's Reference Manual*
[5] R. Startz, *8087 Applications and Programming for the IBM PC and Other PCs,* Robert Brady Co., 1983.
[6] J. Palmer, S. Morse, *The 8087 Primer,* John Wiley, 1984.

Numerical Linear Algebra, Matrix Theory and Applications

[7] G. Golub, C.F Van Loan, *Matrix Computations, Third Edition,* John Hopkins University Press, 1996.
[8] G. Forsythe, M. Malcolm, C. Moler, *Computer Methods for Mathematical Computations,* Prentice Hall, 1977.
[9] P. Gill, W. Murray, M. Wright, *Numerical Linear Algebra and Optimization, Volume I,* Addison-Wesley, 1991.
[10] J. Mathews, *Numerical Methods for Mathematics, Science and Engineering, Second Edition,* Prentice Hall 1992.
[11] W. Press, B. Flannery, S. Teukolsky, W. Vetterling, *Numerical Recipes*,Cambridge University Press, 1986.
[12] P. Ciarlet, *Introduction to Numerical Linear Algebra and Optimisation,* Cambridge University Press, 1989.
[13] T. Harman, J. Dabney, N. Richert, *Advanced Engineering Mathematics Using MatLab V.4,* PWS Publishing, 1997.
[14] R. Malek-Madani, *Advanced Engineering Mathematics with Mathematica and Matlab,* Addison-Wesley, 1998.
[15] Erikson, *A New Operation for Analyzing Series-Parallel Networks*, IEEE Trans. Circuit Theory, CT-6, pp. 124-126, 1959.
[16] E. Deprettere (Editor), *SVD and Signal Processing: Algorithms, Applications and Architectures,* North-Holland, 1988.

Classical Linear Algebra and Matrix Theory

[17] E. Nering, *Linear Algebra and Matrix Theory, Second Edition*, John Wiley, 1970.
[18] G. Strang, *Linear Algebra and Its Applications, Second Edition*, Academic Press, 1976.
[19] J. Wilkinson, *The Algebraic Eigenvalue Problem*, Oxford Science Publications, 1965.
[20] S. Campbell, C. Meyer, *Generalized Inverses of Linear Transformations*, Pitman, 1979.
[21] A. Ben-Israel, T. Greville, *Generalized Inverses: Theory and Applications*, Wiley-Interscience, 1974.
[22] F. Ayres, *Matrices,* Schaum's Outline Series, McGraw Hill, 1962.
[23] S. Lipschutz, *Linear Algebra*, Schaum's Outline Series, McGraw Hill, 1968.
[24] F. Gantmacher, *The Theory of Matrices, Vols. I and II*, Chelsea Publishing Company, 1959.
[25] P. Lancaster, M. Tismenetsky, *The Theory of Matrices*, Second Edition, Academic Press, 1985.
[26] R. Horn, C. Johnson, *Topics in Matrix Analysis*, Cambridge University Press, 1991.
[27] M. Marcus, H. Minc, *A Survey of Matrix Theory and Matrix Inequalities,* Prindle, Weber & Schmidt, 1964.
[28] H. Lutkepohl, *Handbook of Matrices,* John Wiley, 1996.

General Engineering/Applied Mathematics

[29] E. Kreyszig, *Advanced Engineering Mathematics, Seventh Edition*, John Wiley, 1993.
[30] M. Spiegel, *Advanced Mathematics,* Schaum's Outline Series, 1971.